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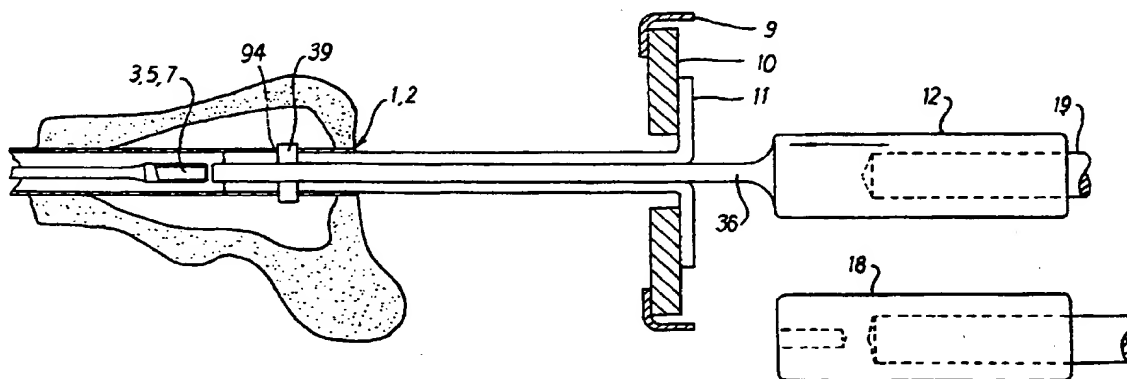
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(54) Title: EXPANDING INTRAMEDULLARY NAIL



(57) Abstract

An intramedullary nail (1) is expandable along its entire length enabling it to be inserted inside a broken bone in its non-expanded form and then expanded so as to secure the bone. Such insertion can be performed without drilling into the bone and the securing of a bone using such a nail alleviates the need for subsidiary pins or nails, thus reducing operation time. Such a nail may consist of a hollow tube with broken cross section which may be expanded by forcing an insert into the break in cross section thus prising it apart.

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1 Expanding Intramedullary Nail

2

3 The present invention relates to an expanding
4 intramedullary nail for uniting bone fragments and to
5 apparatus for operating the nail.

6

7 Conventionally, nails and fixing pins for bone
8 fractures require the bone to be drilled out before the
9 nail or pin can be inserted. This results in loss of
10 tissues which are important for bone growth and healing
11 and can result in fat embolism while drilling. Known
12 devices comprise hollow sleeves accommodating
13 mechanisms, typically for extending flukes to anchor
14 the pin on the inside of the bone.

15

16 One of the disadvantages encountered with known devices
17 is that once the nail or pin is *in situ* it cannot
18 easily be removed; this can cause serious problems if a
19 nail or pin becomes stuck before reaching its final
20 position. Such nails may also need holding in place by
21 other nails, necessitating long operations and
22 sometimes additional operations specifically to insert
23 or remove the subsidiary nails.

24

25 According to the present invention there is provided

1 apparatus for pinning one or more bone elements
2 comprising an intramedullary nail which is selectively
3 cross-sectionally expandable along substantially its
4 entire length, an expander for said nail and operating
5 means for operating said nail in conjunction with said
6 expander.

7

8 Preferably, the nail is elongate and hollow.

9

10 Preferably, the nail is expandable *in situ* within a
11 bone.

12

13 Preferably, the nail has a broken cross section along
14 substantially its entire length and is expandable by
15 enlarging the break in the cross section.

16

17 The nail may be configured so as to be enlargeable by
18 an expander in the form of an elongate insert, inserted
19 into the hollow portion of the nail, where said insert
20 comprises a plurality of elongate members having
21 adjacent cooperating surfaces and configured such that
22 relative axial movement of the elongate members results
23 in their non cooperating surfaces being forced away
24 from each other producing an increase in the total
25 effective cross section of the insert.

26

27 Alternatively, the break in the cross section may be
28 configured so as to accommodate the insertion of an
29 expander or a selected one of a plurality of expanders,
30 each expander being in the form of an elongate member,
31 insertion of said expander prising open the break in
32 the cross section by an amount determined by the size
33 and shape of the expander and each expander having a
34 portion configured so as to be engageable by an
35 expander insertion and/or extraction means.

1 Preferably, the elongate expander has a shaped portion
2 configured to engage a portion of the inside surface of
3 the intramedullary nail configured to have a
4 complementary shape.

5

6 Preferably, there is provided apparatus for expansion
7 and/or reversing said expansion, of the nail comprising
8 engaging means which engage the nail and means for
9 applying or releasing a force to or from said nail.

10

11 Preferably, said apparatus is for insertion and/or
12 extraction of an expander comprising a push and/or pull
13 member which engages the expander, a forcing means
14 which provides force to the push and/or pull member and
15 nail engaging means which helps reduce movement of the
16 nail relative to said apparatus.

17

18 The forcing means may comprise a screw jack mechanism,
19 ratchet mechanism or other substantially non-percussive
20 mechanism.

21

22 Embodiments of the present invention will now be
23 described by way of example with reference to the
24 accompanying drawings in which:

25

26 Fig 1a is a cross-section of an embodiment of an
27 expanding intramedullary nail and a portion of an
28 apparatus for insertion of an expander insert in
29 accordance with the present invention;

30

31 Fig 1b is a cross-section of an embodiment of an
32 expanding intramedullary nail and a portion of an
33 apparatus for withdrawal of the expander insert in
34 accordance with the present invention;

35

1 Fig 2a and Fig 2b are cross-sections corresponding
2 to Figs 1a and 1b of an alternative embodiment;
3
4 Figs 3a-3f are cross-sections of the expanding
5 intramedullary nail of Fig 1 and expander insert
6 in accordance with the present invention;
7
8 Figs 4a-4e are cross-sections of an embodiment of
9 an intramedullary nail and expander inserts,
10 alternative to those shown in fig 3a-3f. Fig 4f
11 is a further embodiment of an intramedullary nail;
12
13 Fig 5a and Fig 5b are side views of an apparatus
14 for operation of an expanding intramedullary nail
15 in accordance with the present invention; the
16 apparatus of Fig 5a is for insertion and the
17 apparatus of Fig 5b for withdrawal of an expander
18 insert;
19
20 Figs 6a, 6b, 7a, 7b, 8a and 8b are side and
21 frontal views showing alternative embodiments of
22 apparatus for operation of an expanding
23 intramedullary nail, in accordance with the
24 present invention;
25
26 Figs 9a, b and c are a broken side view, end view
27 and top view respectively of an intramedullary
28 nail in accordance with the present invention;
29
30 Figs 10a and b are side and end views of an
31 alternative embodiment of an intramedullary nail
32 in accordance with the present invention;
33
34 Figs 11a, b and c, are side, end and top views
35 respectively of an expander of the apparatus of

1 Fig 1a, 1b, 2a or 2b;

2

3 Figs 12a and 12b show side and end views,
4 respectively of an expander of the type
5 illustrated in Figs 4a-4e;

6

7 Figs 13a and 13b show an alternative form of
8 expander insert;

9

10 Fig 14 shows a preferred embodiment of apparatus
11 similar to the apparatus of Figs 6a,b;

12

13 Figs 15a, b show a push member for use with the
14 apparatus of Fig 14;

15

16 Figs 16a,b show a pull member for use with the
17 apparatus of Fig 14; and

18

19 Fig 17 shows a cross section of an intramedullary
20 nail which incorporates a locking mechanism and
21 could be used with the expander of Figs 13a,b.

22

23 Referring to the drawings a first embodiment or
24 embodiments of the present invention shall be presented
25 with reference to Figs 1a, b, 2a, b, 3a-f, 5a,b, 9a-c,
26 and 11a-c. Thereafter further alternative embodiments
27 shall be described with reference to Figs 4a-f, 6a,b,
28 7a,b, 10a,b 7a,b, 12a,b, 13a,b, 14 and 15a,b.

29

30 The first embodiment of the present invention comprises
31 an expandable nail 1 in the form of an elongate tube
32 having a longitudinal slit 30 in the tube wall 31. The
33 expandable nail 1 has a number of expander inserts 3,
34 5, 7 to give a range of degrees of expansion. Each
35 expander insert 3, 5, 7 is formed of an elongate member

1 40 with a screw-threaded attachment end member 41. The
2 elongate member 40 is of generally rectangular cross-
3 section 42 with each expander insert 3, 5, 7 having a
4 different width of a first portion 37 of the
5 rectangular cross-section 42, which portion 37
6 corresponds when *in situ*, with the longitudinal slit 30
7 of the expandable nail 1 (Fig 8c). Six expander
8 inserts 3, 5, 7 are illustrated in Fig 3a to 3f with
9 variable widths of first portion 37 of the rectangular
10 cross-section 42, the widths of the first portion 37
11 vary from 1 to 3.5 mm.

12
13 An expander insertion device 32 has a push rod 12, two
14 draw bars 11, a thrust plate 9, 13 or 14 and a
15 modification to the thrust plate 10. The push rod 12
16 has a thin elongate member 36 a first end of which is
17 attachable to the end member 41 of the expander insert
18 3, 5 or 7, while a second end of the push rod 12 has an
19 attachment sleeve 16 for attachment of a push rod
20 extension 22.

21
22 The insertion device 32 has a sprung ratchet tool 34,
23 attached to an end plate 21 orthogonally situated
24 around the push rod extension 22. The ratchet tool 34
25 is manually operable by means of a handle 38. The end
26 plate 21 is connected to the thrust plate 9 by two tie
27 rods 20, 23 which are disposed on either side of the
28 push rod 12 and push rod extension 22. The thrust
29 plate 9 and end plate 21 have centrally disposed
30 apertures through which the push rod 12 and push rod
31 extension 22 are situated. The ratchet tool 34 is
32 placed against the end plate 21 and pushes the push rod
33 12 linearly along the longitudinal axis of the push rod
34 12 towards the expandable nail 1.

35

1 The draw bars 11 comprise elongate members each having
2 a first end with a transverse pin 39 for location of
3 the draw bar 11 in a fixed position to the expandable
4 nail 1. The pin 39 is situated a short distance from
5 the first end of the draw bar 11 and attached to the
6 proximal end of the expandable nail 1 by engaging a
7 hole 94 in said nail 1. Figs 3a to 3f show a cross-
8 section of the pins 39 of the draw bars 11 and the
9 expandable nail 1. The draw bars 11 and pins 39 are
10 locked into place with respect to the nail 1 by
11 insertion of the push rod 12, 36 between the two draw
12 bars 11.

13
14 A short distance from the second ends of the two draw
15 bars 11, the elongate members bend through 90°. These
16 orthogonal portions of the elongate members project
17 from the longitudinal axis of the push rod 12. The
18 thrust plate 9 and modification 10 are disposed around
19 the draw bars 11 and the push rod 12 such that the
20 orthogonal portions of the draw bars 11 are adjacent to
21 the thrust plate modification 10 on the opposite side
22 of the thrust plate 9 to the expanding intramedullary
23 nail.

24
25 An expander extraction device has a pull rod 15 which
26 is attachable to the end of the expander insert 41
27 within the expandable tube 1. The pull rod 15 has a
28 diameter such that it fits closely within the
29 expandable nail 1. Two pull rods 15, 24 may be
30 connected by means of a screw threaded sleeve 16. A
31 withdrawal thrust plate 13, 14 is positioned against
32 the proximal end of the expandable nail 1 and the
33 thrust plate 13, 14 has a central opening through which
34 the pull rod 15, 24 is positioned. The sleeve 16 is
35 positioned on the opposite side of the thrust plate 13,

1 14 to the expandable nail 1.

2

3 The expander extraction device 33 has a sprung ratchet
4 tool 35 attached to an end plate 25 situated
5 orthogonally around the pull rod 15, 24. The end plate
6 25 and thrust plate 13, 14 are connected by two tie
7 rods 20, 23 which are disposed on either side of the
8 pull rod 15, 24. The end plate 25 and thrust plate 13,
9 14 have centrally disposed apertures through which the
10 pull rod 15, 24 is situated. The ratchet tool 35 is
11 adjacent to the end plate 25 and pulls the pull rod 15,
12 24 linearly along the longitudinal axis of the pull rod
13 15, 24 away from the expandable nail 1.

14

15 In use, the expanding intramedullary nail in its
16 unexpanded form is positioned in its desired position
17 inside a bone along the axis of the bone thereby
18 joining any fracture in the bone.

19

20 The expandable nail 1 is between 8 and 12 mm in
21 diameter depending on the dimensions of the bone and
22 approximately 320 mm long with a minimum wall thickness
23 of 0.5 to 1.0 mm. Intramedullary nails in accordance
24 with the present invention may be of any of a variety
25 of sizes according to the dimensions of the bone.

26

27 The expander insert 3, 5, 7 is inserted into the
28 expandable nail 1 such that the expandable nail 1
29 expands along its whole length. The expander insert 3,
30 5, 7 is inserted with the first portion 37 of the
31 expander insert 3,5,7 corresponding to the longitudinal
32 slit 30 of the expandable nail 1, situated in the slit
33 30. The expandable nail 1 is forced to expand as the
34 width of the first portion 37 of the expander insert is
35 greater than the natural width of the slit 30 in its

1 unexpanded form. The degree of expansion of the
2 expandable nail 1 can be controlled by choice of the
3 appropriately sized expander insert as shown in Fig 3a
4 to 3f.

5
6 The expander inserts 3, 5, 7 are pushed into the
7 expandable nail 1 by use of an expander insertion
8 device 32. The device is arranged as described above
9 such that the action of the sprung ratchet tool 34 can
10 be manually operated by means of a sprung handle 38.
11 Each operation of the handle 38 pushes the push rod 12,
12 22 a discrete distance along the direction of the push
13 rod's 12, 22 longitudinal axis such that it pushes the
14 expander insert into the expandable nail 1.

15
16 The ratchet tool 34 is fixed to the end plate 21 by a
17 weld or braze to a frame projecting from the end plate
18 21. The thrust plate 9 is held a fixed instance from
19 the end plate 21 by the connecting tie bars 20, 23
20 between the plates 9, 21. The draw bars 11 have
21 orthogonal portions situated on the opposite side of
22 the thrust plate 9 to the expandable nail such that the
23 pushing action of the ratchet tool 34 is relayed to the
24 push rod 12 and the expander 3, 5, 7 and does not move
25 the expandable nail 1.

26
27 When the selected expander is fully inserted into the
28 expandable nail 1, the insertion device 32 can be
29 removed. The expander can remain in position until
30 such time as the expansion of the nail is to be
31 reversed, that is, just prior to its repositioning or
32 removal from the bone. The expander extraction device
33 can be positioned with a pull rod 15, 24 attached to
34 the expander insert 3, 5, 7 within the expandable nail
35 1. The thrust plate 13, 14 is positioned against the

1 proximal end of the expandable nail 1 and held in fixed
2 connection with the end plate 25 by tie rods 20, 23.
3 The ratchet tool 35 for withdrawal is fixed to the end
4 plate 25 as described for the ratchet tool 34 for
5 insertion. Each operation of the sprung ratchet tool
6 35 is manually operated by means of a sprung handle 38,
7 pulling the pull rod 15, 24 a discrete distance along
8 the longitudinal axis of the pull rod 15, 24 out of the
9 expandable nail 1.

10

11 On withdrawal of the expander insert 3, 5, 7 the
12 extraction device 33 can be removed.

13

14 Once the expander has been removed, the nail, being
15 made from a resilient material, is allowed to revert to
16 approximately its unexpanded size and shape and can be
17 removed and used again or repositioned if necessary.

18 Thus problems encountered when a nail is wrongly
19 positioned or obstructed before reaching its final
20 position are overcome.

21

22 One form of expandable nail can accommodate a range of
23 sizes of bone and fracture although various sizes of
24 nail would be used according to the circumstances. No
25 drilling of the bone is necessary as the insertion
26 device 32 slowly pushes an expander insert 3, 5, 7 into
27 the expandable nail 1. The nail itself can be
28 positioned manually prior to expansion without drilling
29 because it need only be forced through relatively soft
30 medullary tissue.

31

32 The expandable nail 1 and the expander inserts 3, 5, 7
33 are made of a titanium alloy and all the other
34 components of the apparatus are made of stainless steel
35 except the end plates 25, 21 which are made of mild

1 steel.

2

3 Further embodiments of the present invention will now
4 be described.

5

6 Fig 4a-e shows an alternative cross-sectional
7 configuration for an intramedullary nail and a series
8 of expander inserts to that shown in Fig 3a-f.

9

10 The cross section of the nail of this embodiment is not
11 circular but is configured so as to slidably engage a
12 shaped portion of the expander insert, as the expander
13 is inserted into or withdrawn from the nail.

14

15 This alternative configuration gives greater stability
16 of position of the expander insert as it moves relative
17 to the nail, and also helps prevent rotation of the
18 nail with respect to the bone.

19

20 Fig 4f shows a slightly differently shaped, but
21 functionally similar intramedullary nail to those shown
22 in Figs 4a-e.

23

24 Figs 6a,b, 7a, b and 8a, b show side views (6a, 7a, 8a)
25 and front views (6b, 7b, 8b) of alternative expander
26 insertion/extraction devices 600, 700, 800 to those
27 shown in Fig 5a,b.

28

29 Each of the devices has a similar structure to the
30 devices of Figs 5a, b except that a screw jack
31 mechanism is used in place of the ratchet mechanism and
32 that power can be provided either manually by turning a
33 handle 601 or by an electric motor which is supplied by
34 a lead 704, 804 or possibly battery operated (not
35 shown). Other methods of providing a force, such as

1 hydraulics could also be used.

2

3 Fig 6b shows an expander insertion/extraction device
4 600 having two handles 601, 602 and a threaded rod 603
5 which, when rotated, acts as a screw jack mechanism
6 providing a controllable force for the insertion of an
7 expander into, or extraction of an expander from, an
8 intramedullary nail. The device includes a rear end
9 plate 621 and a front end plate 609 which are connected
10 by tie rods 620, 623. The rear of the threaded rod 603
11 passes through a threaded aperture in the rear end
12 plate 621 and attaches rigidly to a handle 601 such
13 that rotation of the handle 601 also rotates the
14 threaded rod 603 and controls its movement through the
15 aperture in the end plate 621 thus controlling the
16 length of the threaded rod which extends from the rear
17 end plate 621 towards the front end plate 609.

18

19 The threaded rod 603, at its end nearest the front end
20 plate 609, engages a thrust plate 608 which moves along
21 the tie rods 620, 623, that is in a substantially
22 straight line between the front end plate 609 and the
23 rear end plate 621. The thrust plate 608 engages a
24 push/pull member 624 which passes through an aperture
25 in the front end plate 609 and attaches to the expander
26 which is to be forced.

27

28 Thus in use, rotation of the handle 601, which can be
29 performed manually, results in a force, in an axial
30 direction according to the direction of the rotation,
31 on the expander.

32

33 The expander insertion/extraction devices shown in figs
34 7a and 8a, 700, 800 respectively, work in a similar
35 manner to the device 600 and will thus not be described

1 in detail. Corresponding parts of each of the three
2 devices are denoted by three figure numerals in which
3 the first digit denotes the device and the latter two
4 digits are common.

5
6 Two of the devices 700,800 are shown as being operated
7 by an electric motor supplied by a flex 704,804. Thus
8 the handles 701,801 do not rotate and the screw
9 threaded rod does not attach to the handle 701,801 but
10 is driven by the electric motor via transmission
11 components in the housing 770,870.

12
13 The two electrically driven devices 700,800 are
14 operated by use of buttons 750,851,852 located on a
15 handle of the device. One of the devices 800 is shown
16 as having two buttons 851,852 one corresponding to each
17 direction of rotation of the threaded rod.

18
19 The front views of the devices show a vertical member
20 690, 790, 890. This member is for use in attaching the
21 push/pull member to the expander. As an alternative to
22 the screw portion 3 of the expander 40, an expander
23 could be configured with an aperture adjacent to one
24 end of said member as shown in Figure 12. In use the
25 member 690,790,890 passes through the aperture thus
26 securely engaging the expander.

27
28 In Figs. 6a, 7a and 8a the nail extends a distance
29 outside the bone while it is being expanded. Having a
30 portion of the nail extending from the bone has
31 benefits over inserting it so that it is entirely
32 contained within the bone, in that it prevents or
33 reduces the growth of callus over the nail and also
34 facilitates subsequent removal of the nail from the
35 bone.

1 Fig 10 a,b shows an alternative embodiment of an
2 expandable intramedullary nail to that shown in Fig 9
3 a,b,c. The cross sectional shape, shown in Fig 10b, is
4 not round but is shaped to help prevent rotation of the
5 nail relative to the bone and also to help guide a
6 suitably shaped expander into or out of the nail. It
7 can also be seen from Fig 10a that the break in cross
8 section 1030 is flared, widening towards the end where
9 an expander would be inserted. This facilitates the
10 initial insertion of the expander. The end which would
11 be foremost when the nail is inserted into a bone is
12 shaped without sharp corners in order to prevent
13 catching on the inside of the bone and facilitates
14 insertion of the nail into the medullary cavity.

15

16 Fig 12a shows a side view and Fig 12b shows an end view
17 of the type of expander illustrated in Fig. 4. An
18 aperture 1201 is provided as a means of attachment to
19 an insertion or extraction device as described above.

20

21 Figs 13a, b show a further embodiment of an expander
22 for an expanding intramedullary nail comprising two
23 longitudinal sections 1305, 1306 which have teeth with
24 corresponding angled surfaces. The angled surfaces of
25 the teeth are arranged such that a force applied to a
26 first end 1309 of one of the longitudinal sections
27 1302, causing it to move in an axial direction relative
28 to the other longitudinal section 1301, results in
29 angled surfaces of the teeth 1303,1304 moving against
30 each other and gradually disconnecting as shown in Fig
31 13b, causing corresponding motion of the sides of the
32 expander 1305,1306, away from each other.

33

34 In use the expander insert is inserted in its
35 unexpanded form into the intramedullary nail (not

1 shown). Apparatus (not shown) would be provided to
2 force the longitudinal sections 1301, 1302 to move
3 axially relative to each other. Such apparatus might
4 comprise a device such as shown in any one of Figs 5-8
5 with the addition of an attachment means to prevent
6 movement of the longitudinal section of the expander
7 insert which is to remain stationary. Thus the
8 longitudinal sections would be forced to move relative
9 to each other thereby causing the expansion of the
10 expander insert as detailed above.

11
12 The expander insert, on expansion, forces the
13 intramedullary nail to expand with the break in cross-
14 section widening to accommodate the expander insert.

15
16 Use of an expander of this type requires a locking
17 mechanism either on the expander itself, or on the
18 nail. Such a locking mechanism would be necessary to
19 maintain the nail in its expanded state. A locking
20 mechanism on the expander would require the expander to
21 be left in the nail for as long as the expanded state
22 is required. If the locking mechanism were on the nail
23 the expander could be removed leaving the lock expanded
24 nail *in situ* in the patient's bone.

25
26 Fig 14 shows a preferred embodiment of an expander
27 insertion/extraction device 1400 similar to that shown
28 in Fig 6.

29
30 In this embodiment there is a threaded rod 1403 which
31 is hollow and contains a solid rod 1404 which extends
32 through a thrust plate 1408. The solid rod 1404 is
33 attached to a push/pull member 1461 by a locking device
34 1478 which provides two pins 1479, 1480 one of which
35 passes through the solid rod 1404 and of one which

1 passes through the push/pull member 1461. The solid
2 rod 1404 is secured to the thrust plate 1408 by a pin.
3 This arrangement gives secure connection of the
4 threaded rod 1403 to the thrust plate 1408 and
5 push/pull member 1461/1462 during both insertion and
6 extraction procedures.

7
8 The expander insertion/extraction device also includes
9 two pins 1439, which, in use, engage apertures in an
10 intramedullary nail 1401 in order to secure the device
11 to the nail. The pins 1439 are attached to members
12 1440 which engage the outside of the nail 1401, thus
13 differing from the arrangement shown in Figs 1a, 2a and
14 greatly facilitating the insertion of the pins 1439
15 into the apertures. The pins 1439 are secured in the
16 apertures by a circlip 1474 which forces the members
17 1440 against the outside of the nail 1.

18
19 Push and pull members 1461,1462 for use with the device
20 of Fig 14 are shown in Fig 15a,b and 16a,b
21 respectively.

22
23 The push member 1461 consists of a rod which has one
24 end portion configured for attachment to the solid rod
25 1404 via the locking device 1478 and the other end
26 portion configured for engaging, and applying a pushing
27 force to, an expander.

28
29 A pull member 1462 consists of a rod similar to the
30 push member 1461 except that the end portion which
31 engages an expander is configured for the application
32 of a pulling force.

33
34 The portion of the push member 1461 or pull member 1462
35 configured to be attached to the solid rod 1404 of the

1 insertion/extraction device 1400 comprises a flattened
2 part with an aperture. The aperture, in use, engages
3 the pin 1479 which is provided by the locking device
4 1478.

5

6 The portion of the push member 1461 configured to
7 engage the expander comprises a slot into which a
8 portion of the expander fits.

9

10 The portion of the pull member 1462 configured to
11 engage the expander comprises a hook shaped member
12 which, in use, passes through the aperture 1201 of an
13 expander such as that shown in Fig. 12a.

14

15 Fig. 17 shows a cross section of an intramedullary nail
16 according to the present invention which incorporates a
17 locking device such that it could be suitable for use
18 with the expander insert shown in Figs 13a,b.

19

20 The nail comprises a cylindrical tube 1700 with a break
21 in cross section 1704 and a pair of members 1705,1706
22 extending from either side of the break in cross
23 section into the interior of the cylindrical tube 1700.
24 The members 1705,1706 are curved or bent, and
25 configured such that expansion of the tube by
26 increasing the size of the break in cross section
27 causes at least some portions of the members to move
28 longitudinally against each other. The portions of the
29 members which move against each other are each equipped
30 with teeth with inclined surfaces configured such that
31 motion of the members 1705,1706 against each other in
32 the direction that corresponds to expansion of the tube
33 1100 is possible, but motion in the opposite direction
34 is prevented for as long as the teeth 1703 on the two
35 members 1705,1706 engage each other.

1 The two members 1705,1706 include portions 1707,1708
2 spaced apart from each other. These spaced portions
3 1707,1708 are parallel to and proximate to the toothed
4 portions.

5
6 The two members 1705,1706 are configured such that the
7 toothed portions are aligned substantially orthogonal
8 to a radius of the cylindrical tube 1700 that crosses
9 the break in cross section 1704. The members 1705,1706
10 are also configured so as to allow an expander 1701 of
11 the type shown in Fig 13 to be inserted into the
12 cylindrical tube 1700 and occupy a diameter of the tube
13 substantially parallel to the toothed portions of the
14 members 1705,1706.

15
16 In use the tube 1700 is inserted in its unexpanded form
17 into the medullary cavity of the bone to be secured.
18 An expander 1701 of the type shown in Figs 13a,b and
19 described above is then inserted into the hollow
20 portion of the tube 1700.

21
22 An operating means (not shown) is then used to operate
23 the expander 1701 and thus expand the tube by the
24 desired amount. As the tube 1700 expands, the teeth
25 1703 on the members 1705,1706 slide over each other.

26
27 When the desired expansion of the tube has been
28 obtained the expander may be returned to its original
29 configuration (as shown in Fig 13a) and the nail
30 remains expanded, unable to return to its expanded state
31 because of the engaging teeth 1703 on the members
32 1705,1706. The operating means and expander 1701 can
33 thus be removed from the proximity of the nail leaving
34 the nail in its expanded form.

35

1 When the expansion of the nail is to be reversed an
2 elongate member can be inserted into a space, 1702,
3 formed by the spaced apart portions 1707,1708 of the
4 members 1705,1706. Insertion of the elongate member,
5 which is dimensioned to be slightly larger than the
6 natural distance between the spaced apart portions
7 1707,1708 of the members 1705,1706, forces the spaced
8 apart portions 1707,1708 away from each other thus
9 disengaging the teeth and allowing the tube 1700 to
10 revert to its unexpanded form.

11

12 Improvements and modifications may be incorporated
13 without departing from the scope of the invention.

1 CLAIMS

2

3 1 Apparatus for pinning one or more bone elements
4 comprising an intramedullary nail being
5 selectively cross-sectionally expandable along
6 substantially the entire length of the nail, an
7 expander for said nail, and operating means for
8 operating said nail in conjunction with said
9 expander.

10

11 2 An intramedullary nail being selectively cross
12 sectionally expandable along substantially the
13 entire length of the nail.

14

15 3 A nail as claimed in Claim 2 wherein the nail is
16 hollow and elongate.

17

18 4 A nail as claimed in either of Claims 2 or 3
19 wherein the nail is expandable *in situ* within a
20 bone.

21

22 5 A nail as claimed in any one of Claims 2 to 4,
23 wherein the nail has a broken cross section
24 throughout substantially its entire length and is
25 expandable by enlarging the break in the cross
26 section.

27

28 6 A nail as claimed in any one of Claims 3 to 5,
29 wherein the nail is configured so as to be
30 enlargeable by an expander in the form of an
31 elongate insert, inserted into the hollow portion
32 of the nail.

33

34 7 A nail as claimed in Claim 5 wherein the break in
35 cross section is configured so as to accommodate

1 the insertion of an expander or successive
2 insertion of a plurality of expanders, each
3 expander being in the form of an elongate member.
4

5 8 An expander for use in the apparatus of Claim 1,
6 comprising a first portion for engagement of an
7 intramedullary nail and a second portion
8 configured to be engaged by an operating means for
9 said nail and expander.

10
11 9 An expander as claimed in Claim 8 wherein the
12 expander is in the form of an elongate insert for
13 insertion into a hollow portion of an expandable
14 intramedullary nail.
15

16 10 An expander as claimed in Claim 9 wherein the
17 elongate insert comprises a plurality of elongate
18 members having cooperating surfaces and configured
19 such that relative axial movement of the members
20 results in their non-cooperating surfaces being
21 forced away from each other effecting an increase
22 in the total cross section of the insert.
23

24 11 An expander as claimed in Claim 8 or 9 wherein the
25 first portion is insertable into the break in
26 cross section of the nail of Claim 5, and is
27 adapted to prise open the break by an amount
28 determined by the size and shape of the expander,
29 and the second portion is configured so to be
30 engageable by an expander insertion/extraction
31 means.
32

33 12 An expander as claimed in Claim 11 having a shaped
34 portion configured to engage a portion of the
35 inside surface of an intramedullary nail

1 configured to have a complementary shape.

2

3 13 Operating means for use with an intramedullary
4 nail, said nail being expandable along
5 substantially its entire length, comprising
6 engaging means which engages the nail and means
7 for applying or releasing a force to or from said
8 nail.

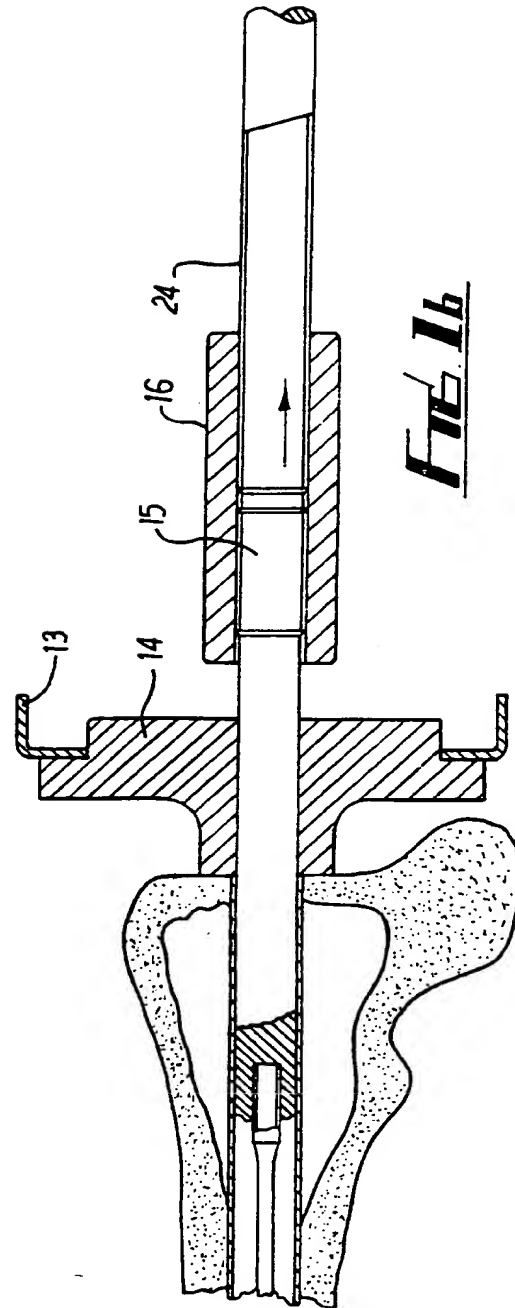
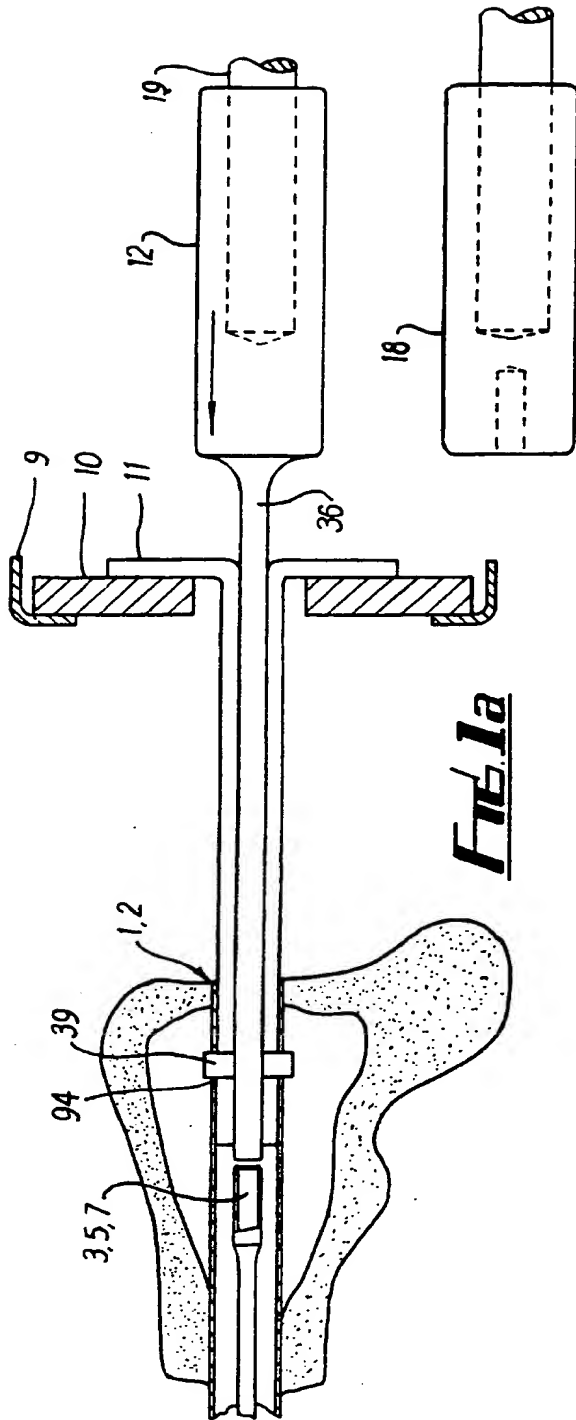
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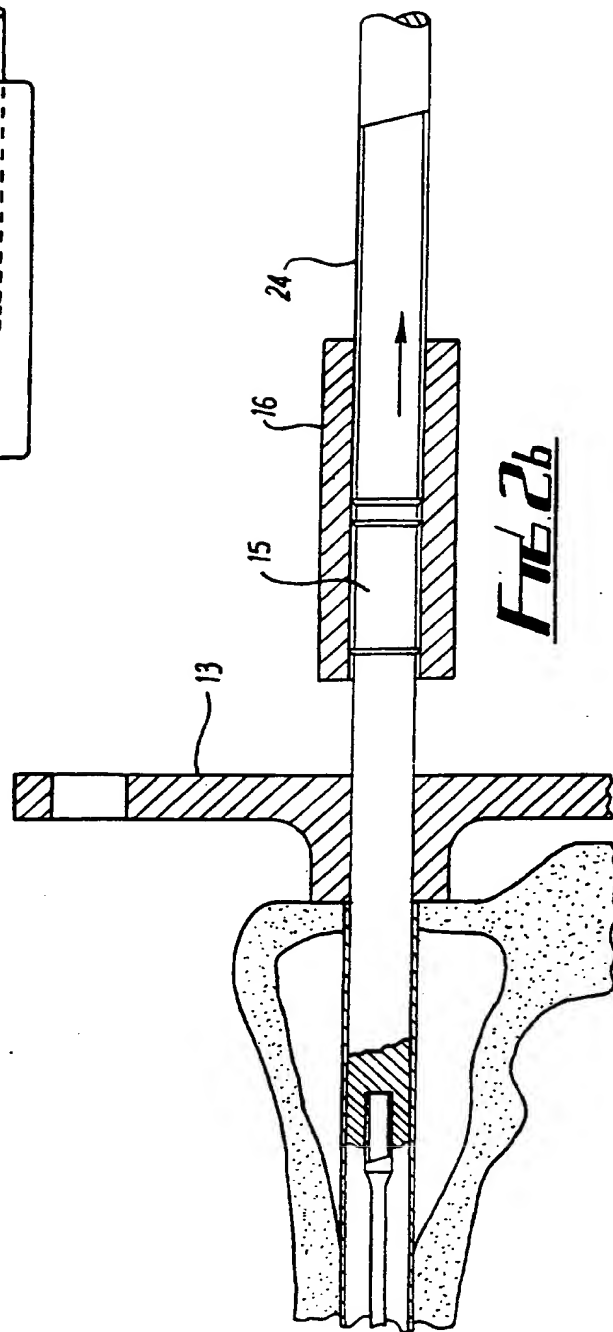
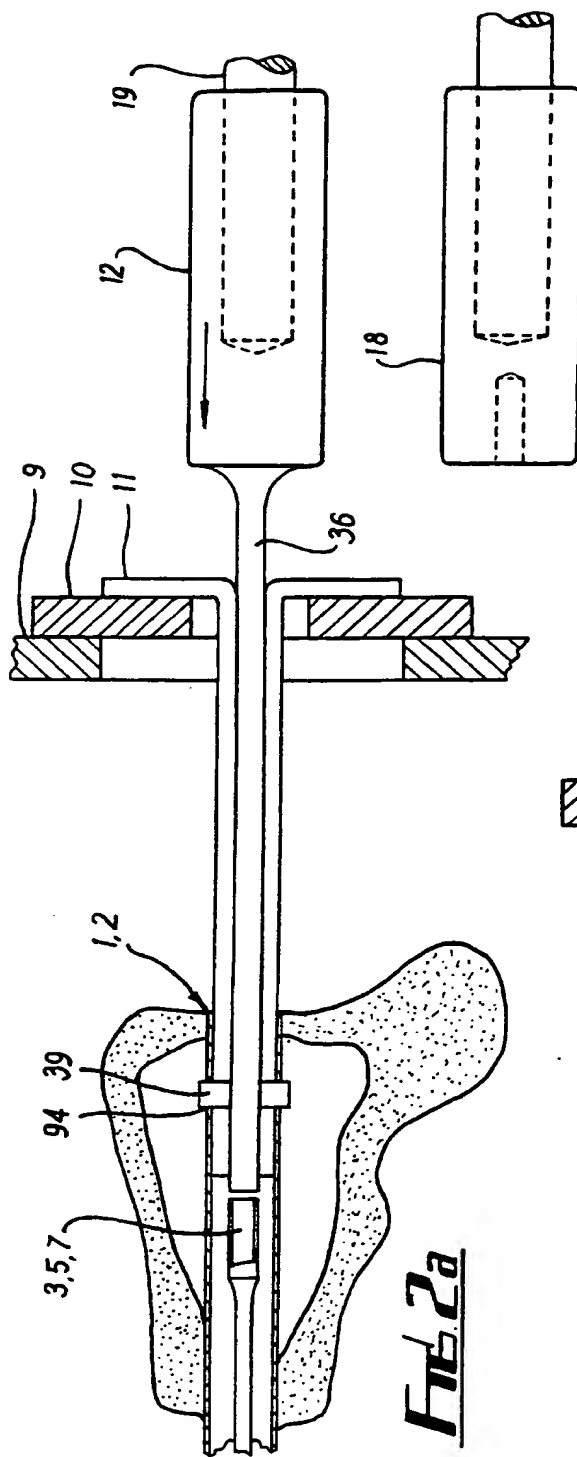
10 14 Operating means as claimed in Claim 13, being
11 adapted for the insertion and/or extraction of an
12 expander, comprising a push and/or pull member
13 adapted to engage the expander, forcing means
14 which provides force to the push and/or pull
15 member and nail engaging means, which in use,
16 braces the nail against the operating means.

17

18 15 Operating means as claimed in Claim 13 or 14
19 wherein the forcing means comprises a screw jack
20 mechanism, ratchet mechanism or other
21 substantially non-percussive mechanism.

22





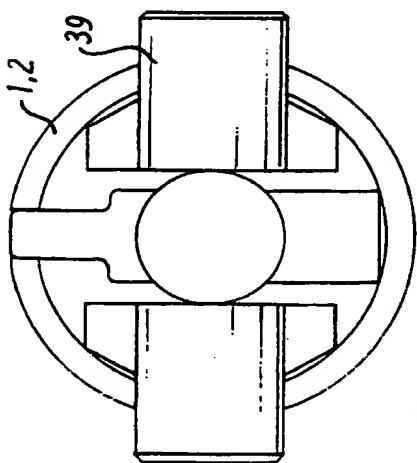


Fig. 3a

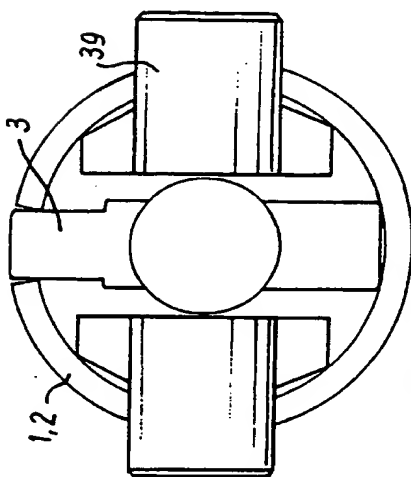


Fig. 3b

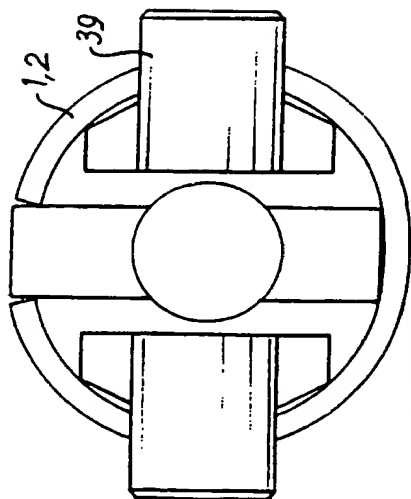


Fig. 3c

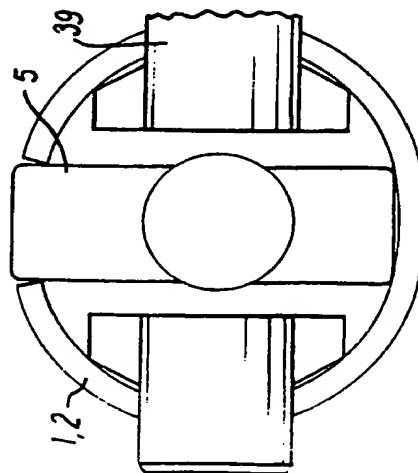


Fig. 3d

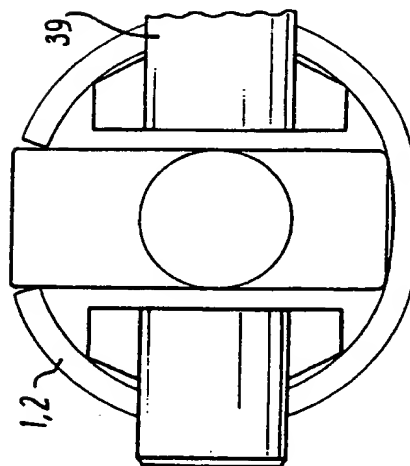


Fig. 3e

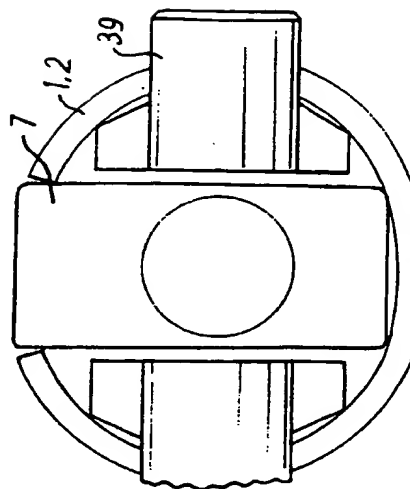


Fig. 3f

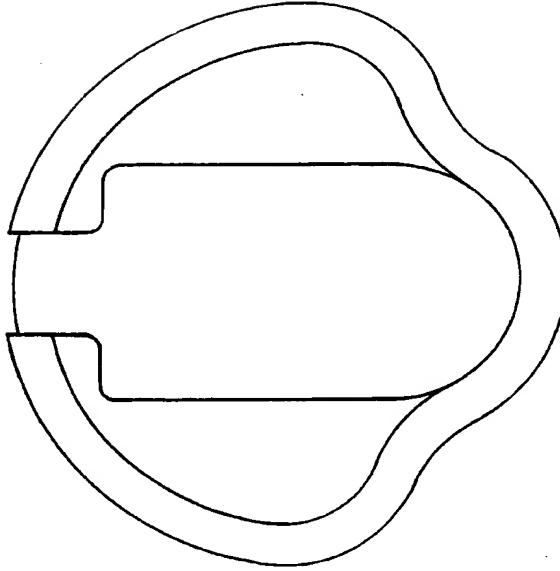


Fig 4b

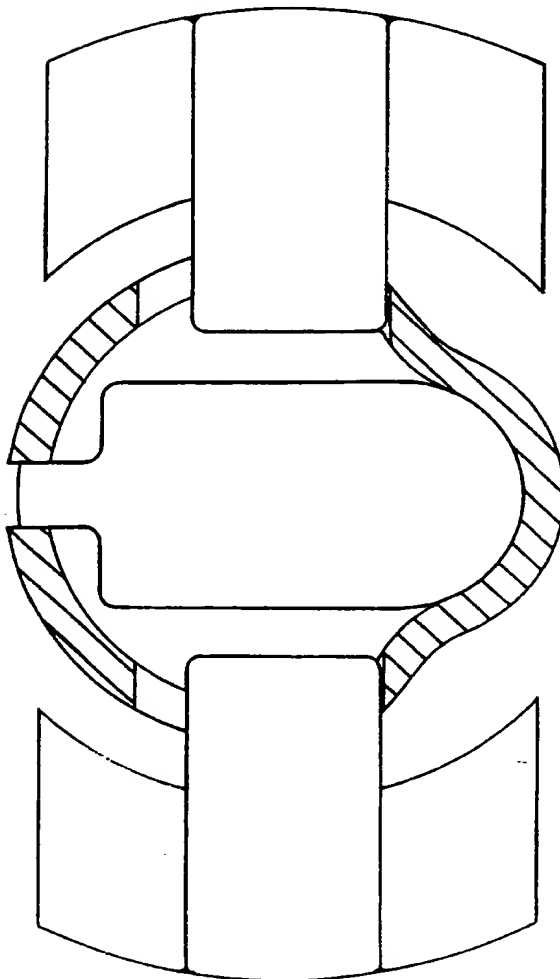


Fig 4a

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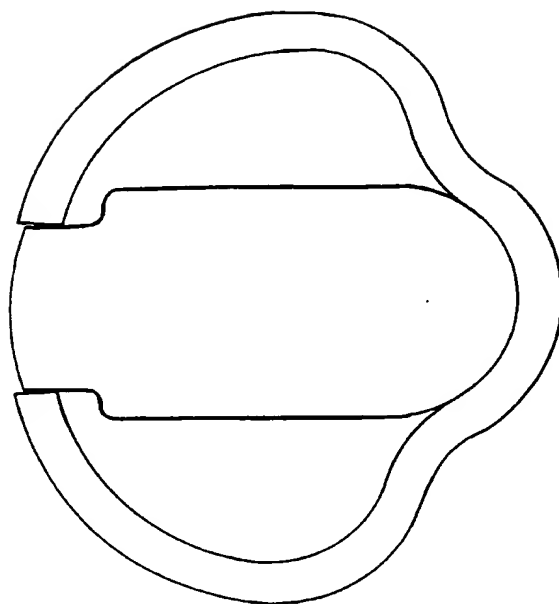


Fig. 4d

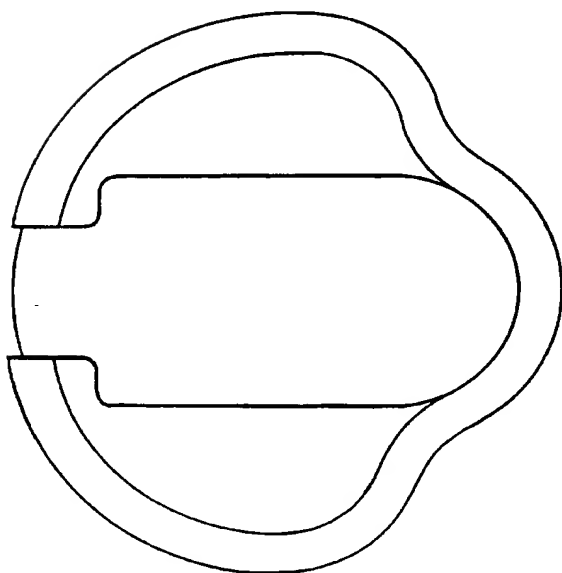


Fig. 4c

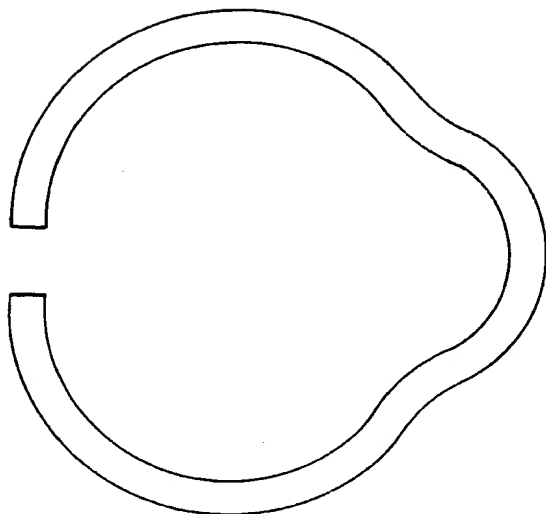


Fig. 4f

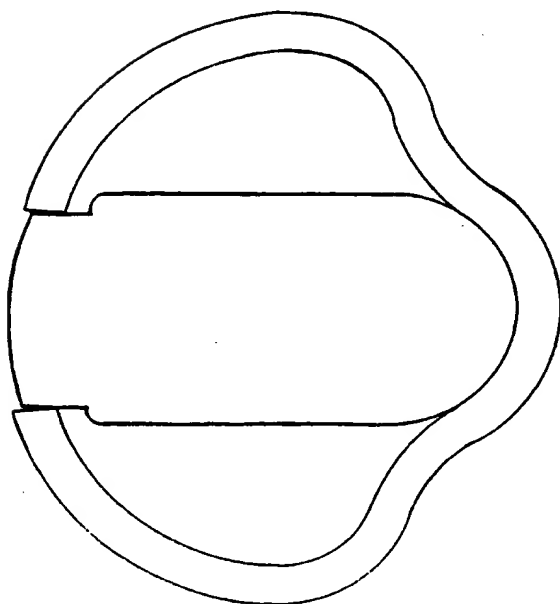
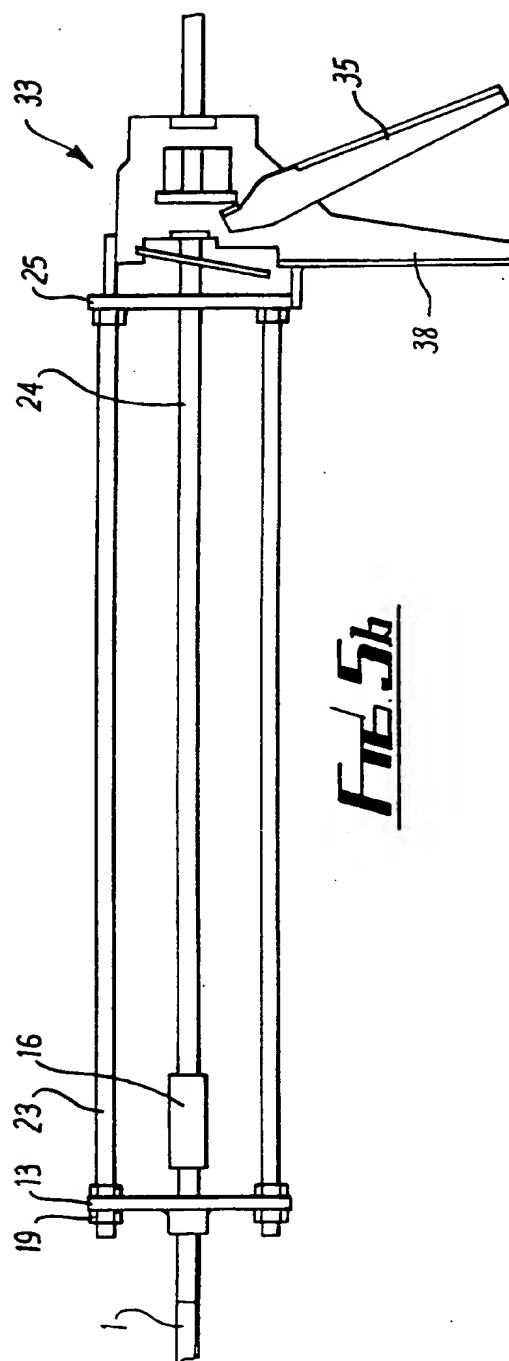
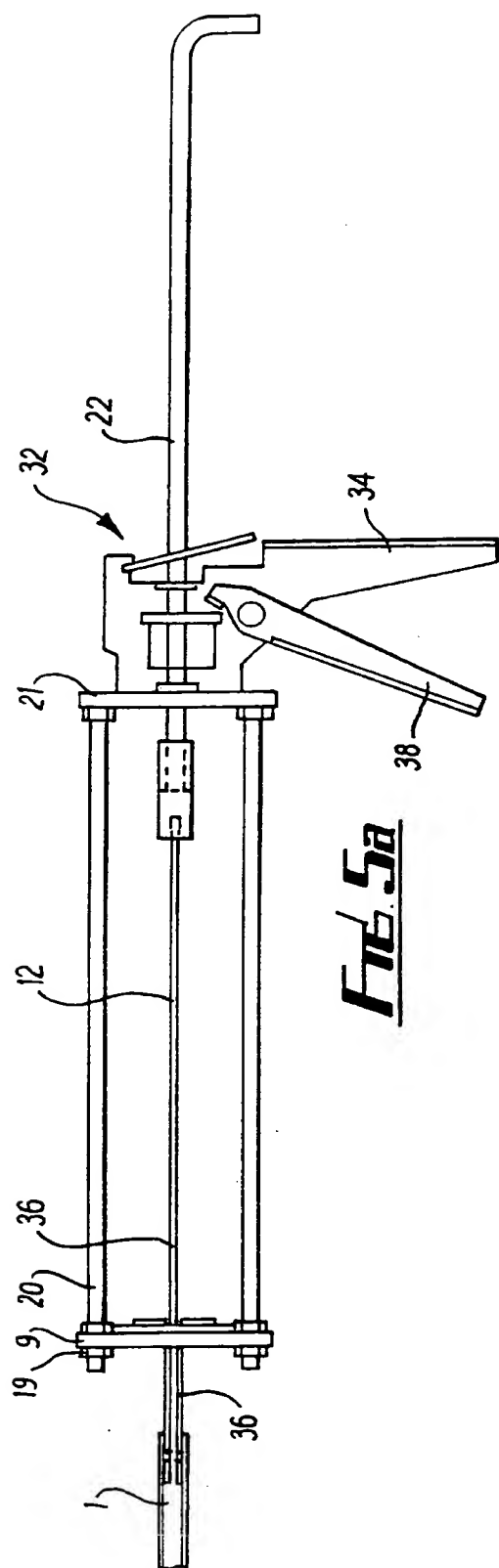
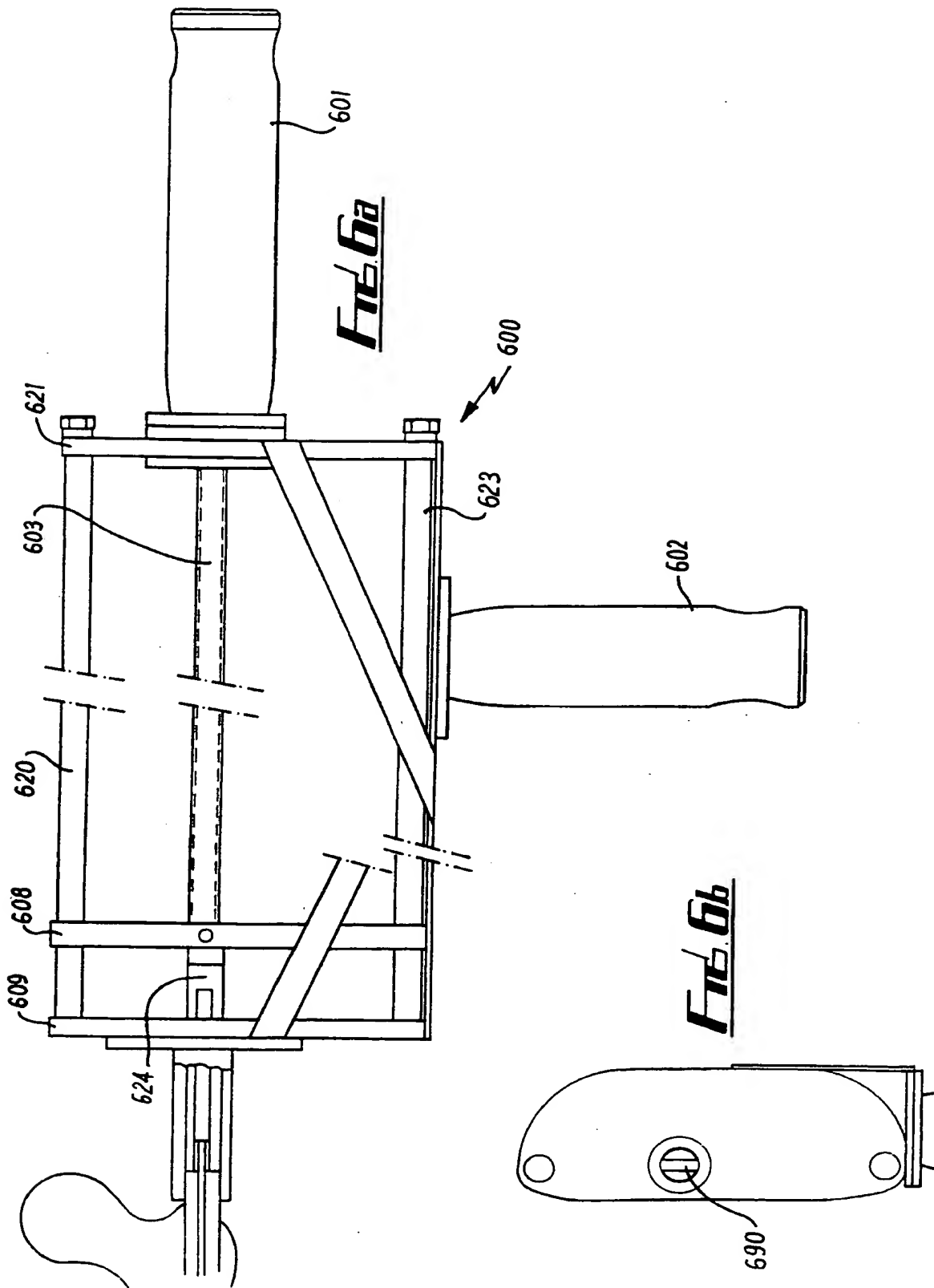
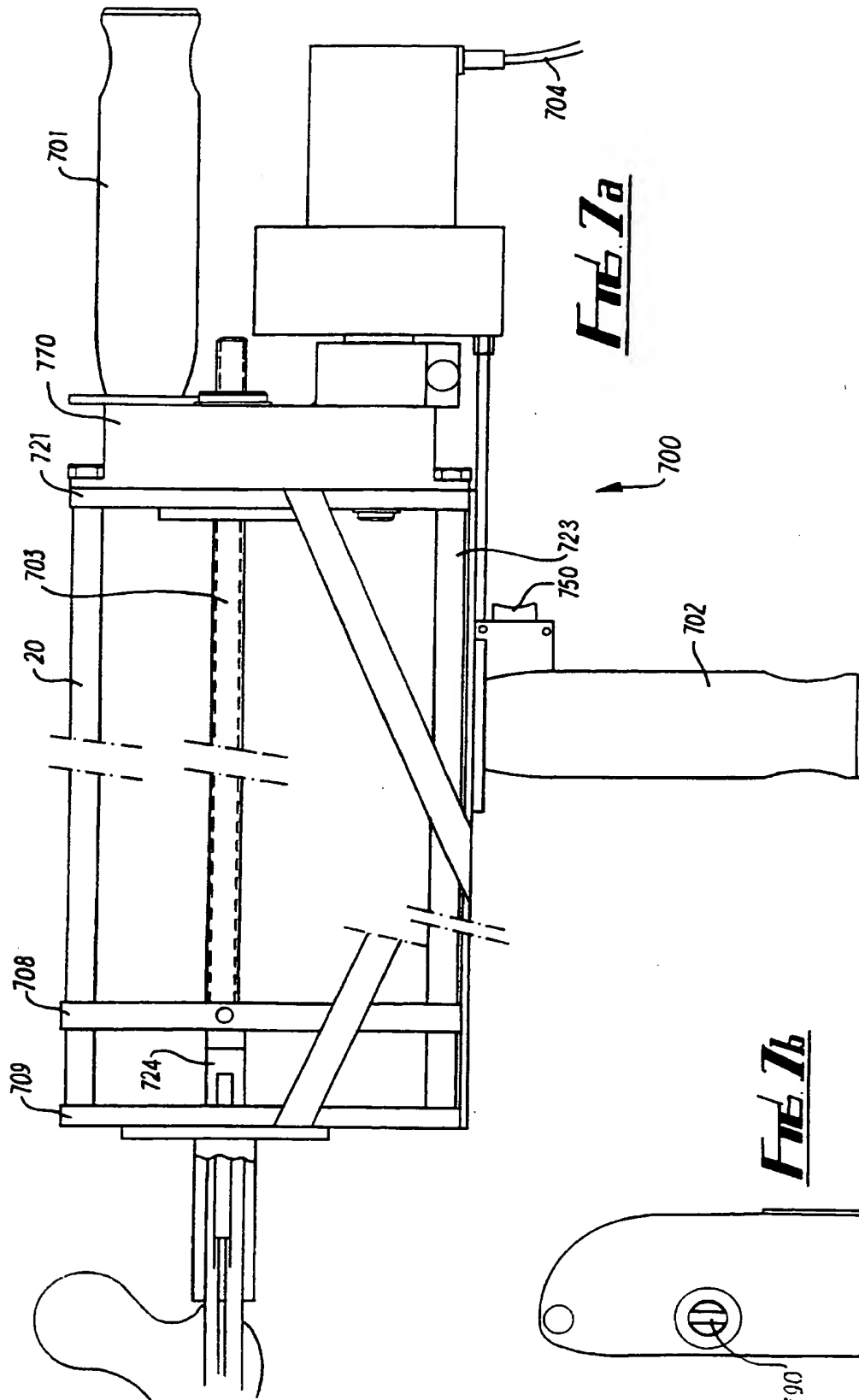
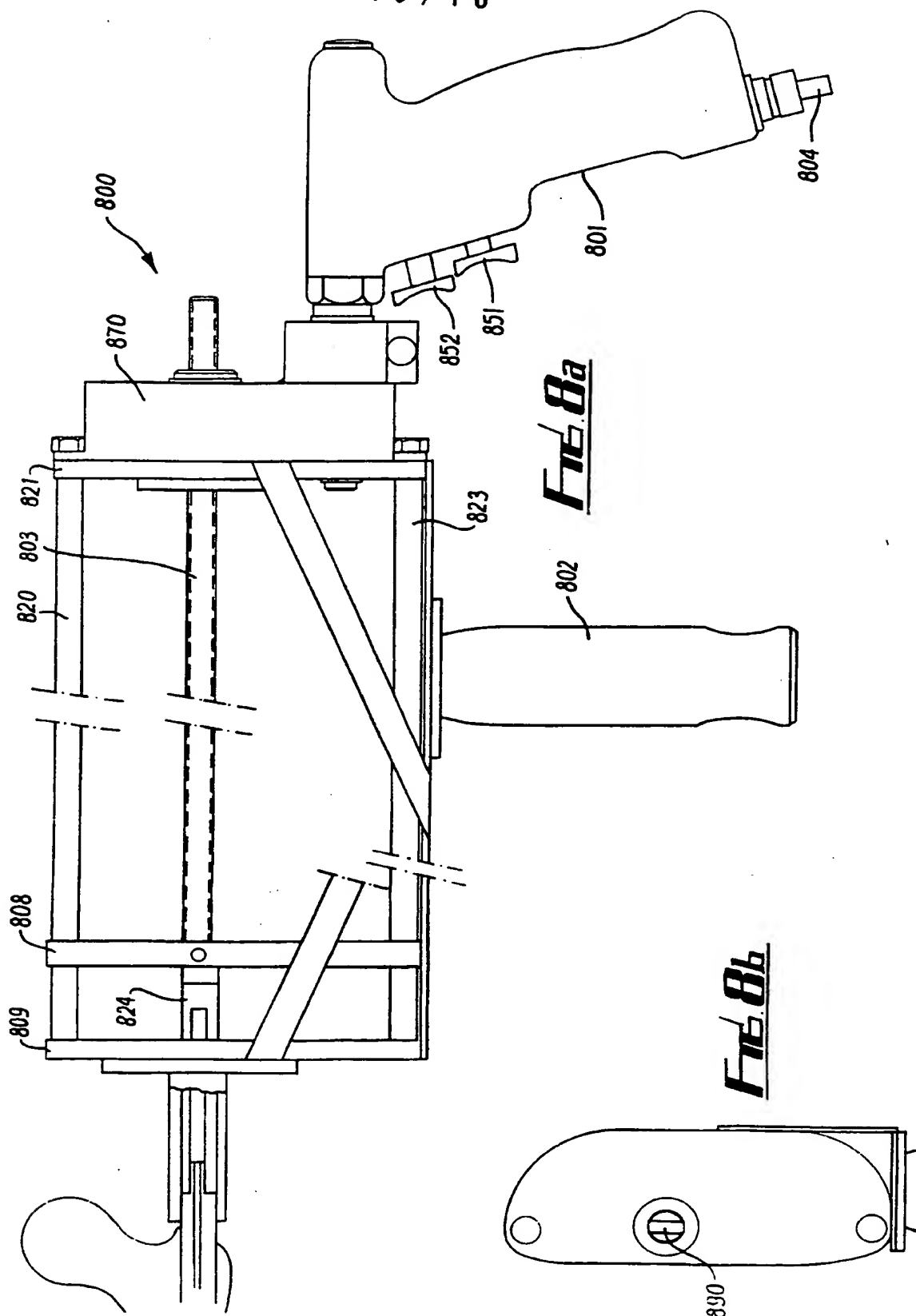


Fig. 4e









SUBSTITUTE SHEET

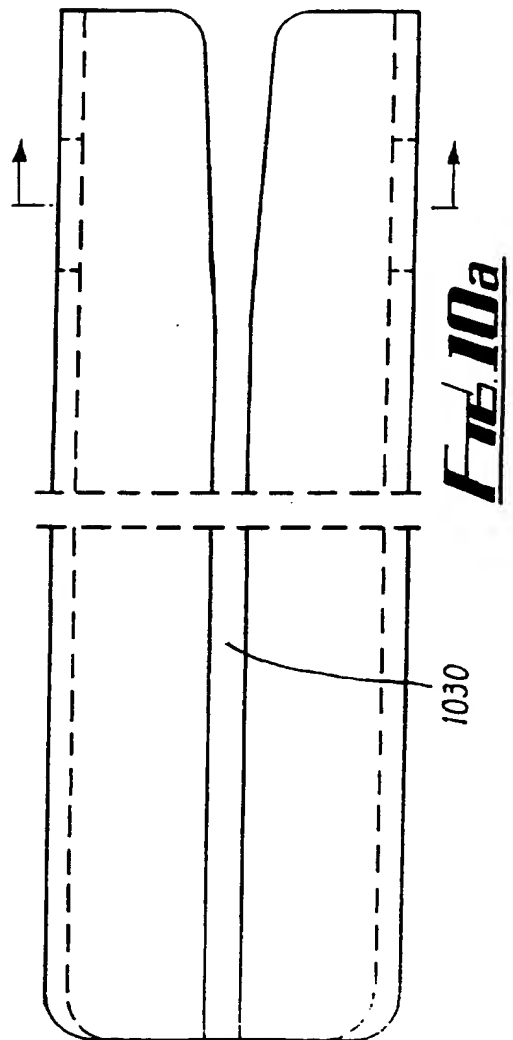
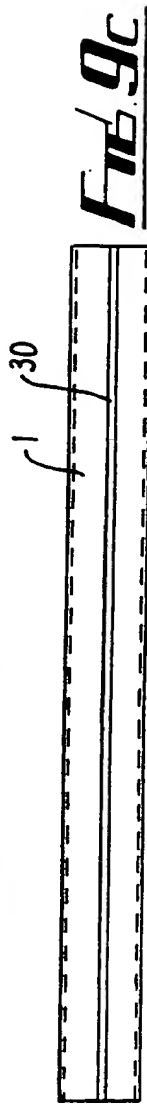
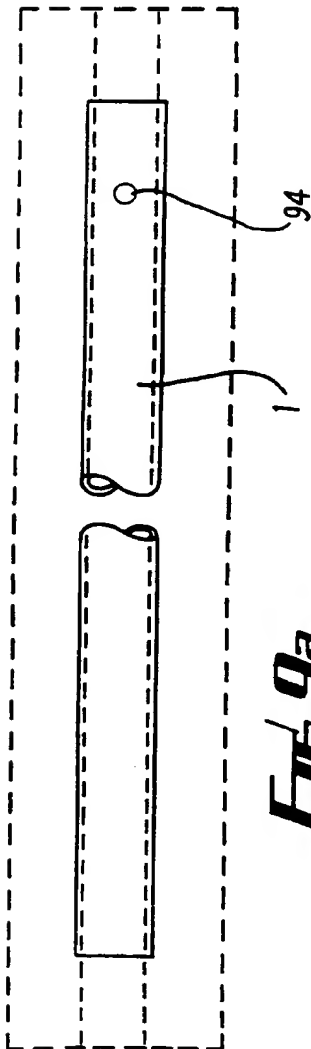
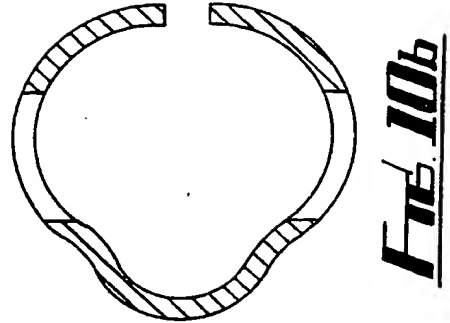
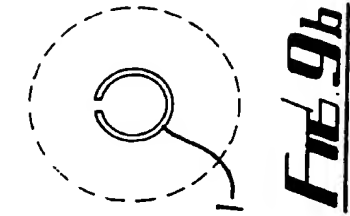




Fig. 11a



Fig. 11b



Fig. 11c

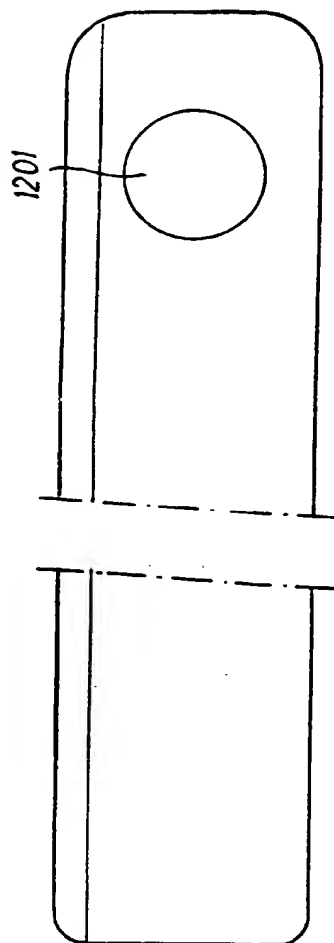
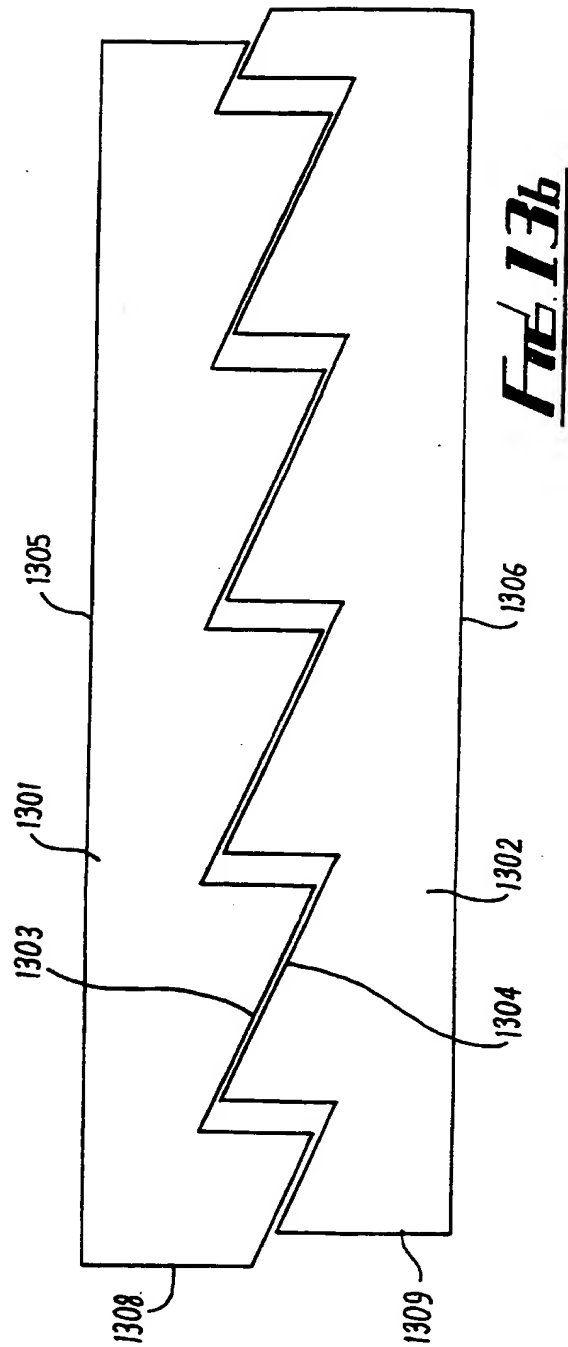
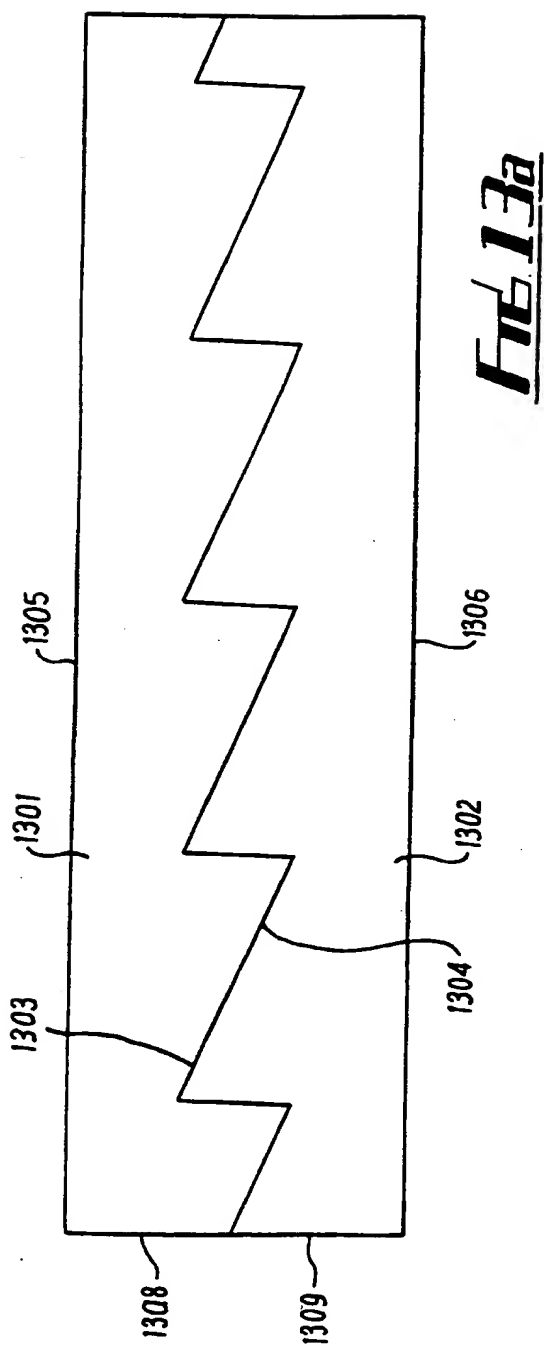


Fig. 12a



Fig. 12b



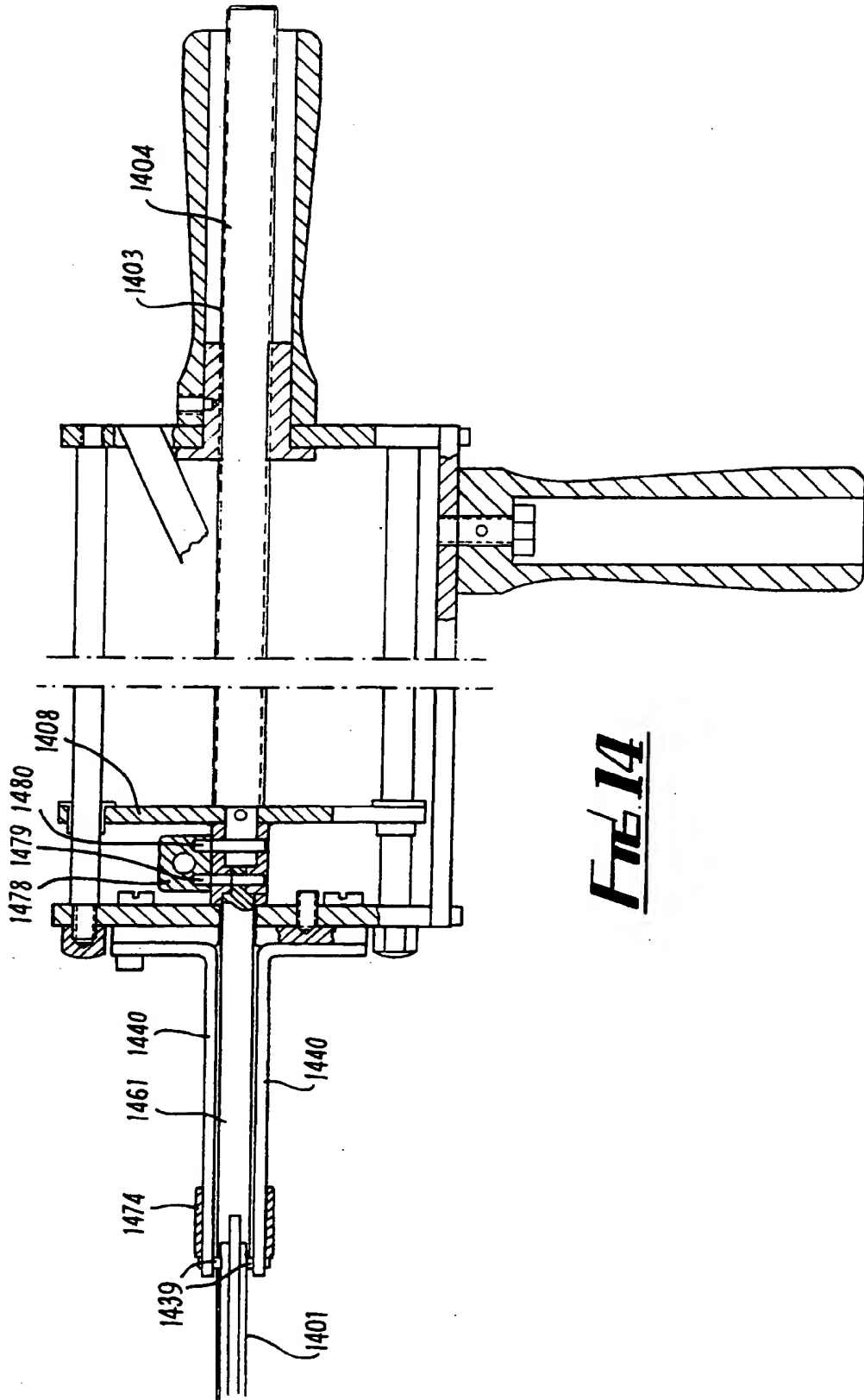
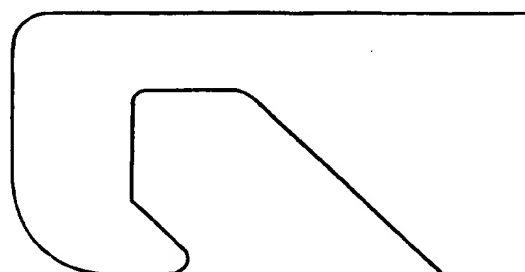
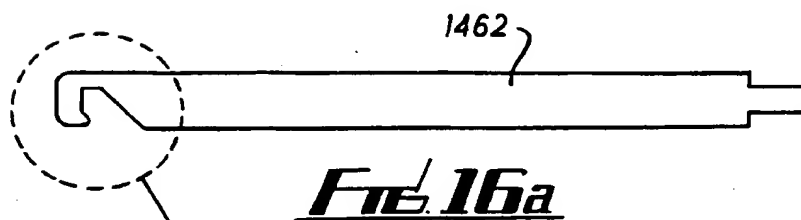


Fig. 14



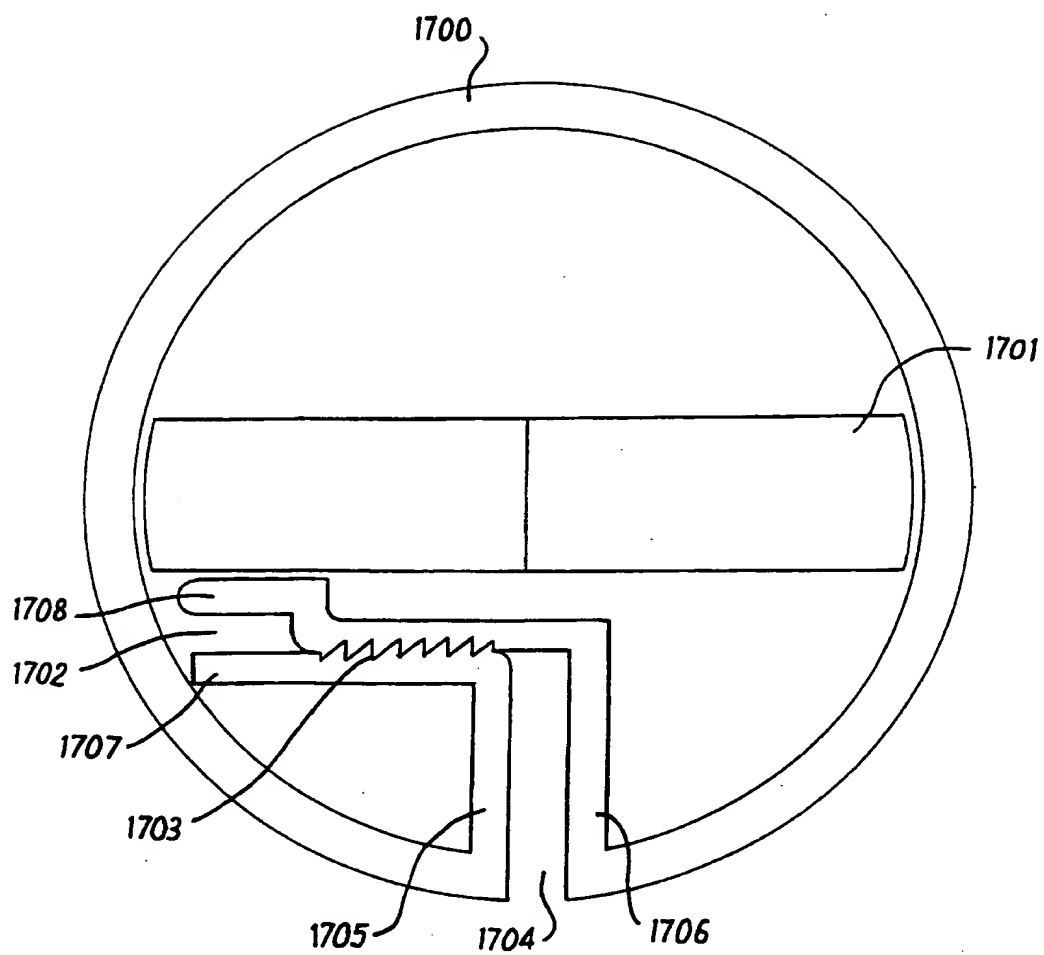


FIG. 17

INTERNATIONAL SEARCH REPORT

Inter. Appl. No.
PCT/GB 93/02390

A. CLASSIFICATION OF SUBJECT MATTER
IPC 5 A61B17/58

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC 5 A61B A61F

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category * | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|------------|--|-----------------------|
| X | DE,C,745 873 (POHL) 10 August 1953 see the whole document --- | 1-9, 11-13, 15 |
| A | US,A,5 116 335 (HANNON) 26 May 1992 see claim 1; figures --- | 10 |
| A | DE,U,84 00 640 (MECRON) 20 June 1985 see figures 3,4 --- | 14 |
| A | US,A,4 854 312 (RAFTOPOULUS) 8 August 1989 --- | |
| A | WO,A,88 01492 (OFFICE MEDICO CHIRURGICAL INTERNATIONAL) 10 March 1988 --- | |
| A | US,A,4 531 517 (FORTE) 30 July 1985 ----- | |

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

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Date of the actual completion of the international search

10 March 1994

Date of mailing of the international search report

25.03.94

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/GB 93/02390

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
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| US-A-5116335 | 26-05-92 | NONE | |
| DE-U-8400640 | 20-06-85 | NONE | |
| US-A-4854312 | 08-08-89 | NONE | |
| WO-A-8801492 | 10-03-88 | FR-A- 2606997 | 27-05-88 |
| | | EP-A- 0278963 | 24-08-88 |
| | | US-A- 4911722 | 27-03-90 |
| US-A-4531517 | 30-07-85 | NONE | |